example, aqueous potassium hydroxide. After wells **8** are formed, fluid channels **9** can be formed in the silicon wafer **6** as depicted in FIG. **3**E. Next, the magnetic traps **1** were formed using a photoresist and sputter depositing a tantalum adhesive layer of 5 μm and a PERMALLOY™ layer of 30 μm as depicted in FIG. **3**F. The arrays of traps **1** etched across each portion of the nitride membrane that extends across the bottoms of each of the wells **8** is referred to herein as the spin-valve elements. The individual traps **1** are referred herein to as traps or spin-valve traps. From FIGS. **3**A-**3**E it can be understood that a single chip or micromachined magnetic trap platform can include a plurality of spin-valve elements (arranged in an array) each or which includes a plurality of spin-valve traps **1** that are also arranged in an array.

According to the present invention micromachined magnetic trap platforms can have a plurality of magnetic trap arrays each of which can have 50 to 200 traps with each trap being 1.2 μm×3.6 μm, it being understood that these dimensions and number or traps are non-limiting examples only and that the dimensions and number or traps can easily be varied as desired.

The single layered traps of FIGS. **1**-**3** (not counting the tantalum adhesive layer, can be activated (stitched "ON" or "OFF") by application of an applied magnetic field. According to further embodiments of the present invention multilayered spin-valve traps are provided which can be switched "ON" and "OFF" in groups or individually by application of an auxiliary magnetic field that can be applied selectively and as a short pulse as discussed below.

FIG. **4** is a schematic side view of a spin-valve trap according to one embodiment of the present invention. The spin-valve trap depicted in FIG. **4** includes two layers of magnetic permeable or ferric material exemplified as PERMALLOY™ **10**, **11** which are separated by an intermediate layer of copper **12**. Note shown in FIG. **4** is a lower layer of tantalum which would normally be provided as an adhesive layer to secure the multilayered spin-valve trap to a membrane.

FIG. **5** is a schematic side view of a spin-valve trap according to another embodiment of the present invention. The spin-valve trap depicted in FIG. **5** includes a layer of tantalum **13**, a layer of PERMALLOY™ ($Ni_{80}Fe_{20}$) **14**, a layer of cobalt **15**, a layer of copper **16**, a layer of cobalt **17**, a layer of PERMALLOY™ ($Ni_{80}Fe_{20}$) **18**, a layer of IrMn **19** and a later of tantalum **20** as shown. According to one embodiment the layer **13** of tantalum was 5 nm, the layer **14** of PERMALLOY™ ($Ni_{80}Fe_{20}$) was 15 nm, the layer **15** of cobalt 5 nm, the layer **16** of copper was 10 nm, the layer **17** of cobalt was 5 nm, the layer **18** of PERMALLOY™ ($Ni_{80}Fe_{20}$) was 15 nm, the layer **19** of IrMn was 5 nm and the layer **20** of tantalum was 5 nm. The lower layer of tantalum **20** functions as an adhesive between the spin-valve trap and the membrane to which is attached and the top layer of tantalum **13** acts as a barrier to oxidation. The cobalt layers **15** and **17** act as diffusion barriers between the PERMALLOY™ ($Ni_{80}Fe_{20}$) layers **14** and **18** and the Cu spacer layer **16**. According to one embodiment, a spin-valve trap as illustrated in FIG. **5** was fabricated having a width of 1 micrometer in width and a length of 4 micrometers. It is to be understood that the dimensions of the elements discussed herein including the spin-valve elements and spin-valve traps and the thickness of the various layers of the spin-valve traps and membrane are not limited to the specific examples given and could be varied as desired.

FIG. **6** is an M-H curve of a spin-valve element that depicts the bistable state at H=0 Oe. As shown in FIG. **6**, the spin-valve elements exhibit a bistable magnetic structure that encompasses a ferromagnetic "ON" and antiferromagnetic "OFF" state in the absence of an applied magnetic or current-induced magnetic field. Since the spin-valve arrays and spin-valve elements are arrayed, the location of the traped particle can be specified by a matrix position with respect to all other spin-valve arrays and spin-valve elements in the arrays. The magnetization of the spin-valve elements can be macroscopically turned "ON" and "OFF" by applying an applied magnetic field of the appropriate magnitude and polarity or individually turned "ON" and "OFF" by applying the appropriate current-induced magnetic fields to each individual spin-valve array or each individual spin-valve element.

In the "OFF" state, the spins in the free layer of each spin-valve element are aligned antiparallel to the spins in the pinned layer. The fields from each layer cancel one another effectively leaving the trap non-magnetic in nature. In this case, particles would not be attracted to the trap and would be free to seek out the closest region with a high magnetic field gradient. In the "ON" state, the free layer in the trap is aligned with the pinned layer, thereby producing a magnetic field gradient that is strongest at the ends of the trap. In this state, the particles are trapped in the local magnetic field gradient of each spin-valve element. When using current induced magnetic fields, each individual spin-valve arrays or individual spin-valve elements can be turned "ON" and "OFF". The proper sequence of "ON/OFF" events produces sorting of magnetic particles by the stationary array of spin-valve elements in any portion of its respective spin-valve array as illustrated in FIG. **7** where the magnetic particles **21** are depicted as being attached to spin-valve elements **22** that are in their "ON" state. In addition, magnetic particles can be moved between adjacent spin valve elements with an appropriate pulse sequence. Finally, a movable tip with a spin-valve element on the end can also be used to sort the particles as discussed in more detail below.

Since there is a minimum magnetic field necessary to flip between states, a second magnetic field can be applied to systems of the present invention that include multilayered spin-valve elements. For example, in the "ON" state, a second magnetic field of sufficient strength to rotate the particle, but of insufficient strength to change the ferromagnetic character of the spin-valve arrays or relevant traps, can be applied to provide torsional/rotational manipulation to samples (e.g. biological specimens, chemical compounds, etc.) that can be attached to the trapped magnetic particles.

FIGS. **8**A-**8**C depict various geometries for the application of a rotational magnetic field to a biopolymer (DNA) **25** that is held by opposite ends **26** by separated spin-valve traps **1**. The rotation of the magnetic field can be about the X, Y or Z axes. Since the direction of rotation (i.e., clockwise or counterclockwise) is the same for all particles, rotation about the Y and X axes (FIGS. **8**B and **8**A) will not allow for the application of torque to biological molecules **25**. For rotation about the X-axis, the entire molecule **25** will rotate about a fixed point as indicated in FIG. **8**A. For rotation about the Y-axis, it is possible for the molecule **25** to flip to alleviate the any applied torsional force as indicated in FIG. **8**B. For rotation about the Z-axis, torsional force can be applied to the molecule **25** as depicted in FIG. **8**C. For this geometry, it is noted that the attachment points of the molecule **25** to the magnetic particle point must both point away from the membrane surface. This can be accomplished by providing steric hinderance in the form of small grooves in the membrane.

According to experiments conducted during the course of the present invention, a rotational field of approximately 12 Oe with a 0.003 T/cm magnetic field gradient was determined to be sufficient to rotate particles about spin-valve elements in an array of a spin-valve element. The small magnitude of the rotational field had a negligible effect on the trap magnetiza-